Saturn Scatterometry Rev 277

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- Sequence: s100
- Rev: 277
- Observation Id: ri_277_1
- Target Body: Saturn

1 Introduction

This memo describes one of the Cassini RADAR activities for the s100 sequence of the Saturn Tour. A sequence design memo provides the science context of the scheduled observations, an overview of the pointing design, and guidelines for preparing the RADAR IEB. A 3-hour warmup occurs first using the parameters shown in table 3.

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
277RI_WARMUP002_RIDER	2017-154T22:40:00	2017-155T01:42:00	03:02:0.0	
277RI_OUTBHIRES002_PIE	2017-155T01:42:00	2017-155T03:42:00	02:00:0.0	

Table 1: ri_277_1 CIMS Request Sequence

Each RADAR observation is represented to the project by a set of requests in the Cassini Information Management System (CIMS). The CIMS database contains requests for pointing control, time, and data volume. The CIMS requests show a high-level view of the sequence design.

The CIMS requests form the basis of a pointing design built using the project pointing design tool (PDT). The details of the pointing design are shown by the PDT plots on the corresponding tour sequence web page. (See https://cassini.jpl.nasa.gov/radar.) The RADAR pointing sequence is ultimately combined with pointing sequences from other instruments to make a large merged c-kernel. C-kernels are files containing spacecraft attitude data.

A RADAR tool called RADAR Mapping and Sequencing Software (RMSS) reads the merged c-kernel along with other navigation data files, and uses these data to produce a set of instructions for the RADAR observation. The RADAR instructions are called an Instrument Execution Block (IEB). The IEB is produced by running RMSS with a radar config file that controls the process of generating IEB instructions for different segments of time. These segments of time are called divisions with a particular behavior defined by a set of division keywords in the config file. Table 2 shows a summary of the divisions used in this observation. Subsequent sections will show and discuss the keyword selections made for each division. Each division table shows a set of nominal parameters that are determined by the operating mode (eg., distant scatterometry, SAR low-res inbound). The actual division parameters from the config file are also shown, and any meaningful mismatches are flagged.

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	-3:00:0.0	02:59:0.0	2.7	Warmup
b	distant_radiometer	-0:01:0.0	00:02:12.0	0.1	Radimeter division replaced by custom dust probe
c	scat_compressed	00:01:12.0	00:20:48.0	3.7	scat compressed while off target
d	sar_lo_rings	00:22:0.0	00:00:24.0	2.4	sarl during turn transition
e	scat_rings	00:22:24.0	00:03:36.0	21.6	scatt during turn transition
f	scat_rings	00:26:0.0	00:04:0.0	26.4	scatt on C-ring, still turning on track
g	scat_rings	00:30:0.0	00:05:0.0	57.0	scatt on C-ring
h	scat_rings	00:35:0.0	00:08:0.0	91.2	scatt on C-ring
i	scat_rings	00:43:0.0	00:05:0.0	51.0	scatt on C-ring
j	scat_rings	00:48:0.0	00:08:0.0	76.8	scatt on C-ring
k	scat_rings	00:56:0.0	00:03:0.0	30.6	scatt on B-ring
l	sar_lo_rings	00:59:0.0	00:04:0.0	46.8	sarl on B-ring
m	sar_lo_rings	01:03:0.0	00:27:0.0	328.9	sarl on B-ring
n	sar_lo_rings	01:30:0.0	00:26:0.0	316.7	sarl on B-ring
o	sar_lo_rings	01:56:0.0	00:04:0.0	37.2	sarl on A-ring
p	distant_radiometer	02:00:0.0	01:00:0.0	3.6	Closing Radiometer
Total				1096.6	

Table 2: Division summary. Data volumes (Mbits) are estimated from maximum data rate and division duration.

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	varies	-180.0	no	
end_time (min)	varies	-1.0	no	
time_step (s)	varies	3600.0	no	Used by radiometer only modes - saves commands
bem	00100	00100	no	
baq	don't care	5	no	
csr	6	6	no	6 - Radiometer Only Mode
noise_bit_setting	don't care	4.0	no	
dutycycle	don't care	0.38	no	
prf (Hz)	don't care	1000	no	
tro	don't care	0	no	
number_of_pulses	don't care	8	no	
n_bursts_in_flight	don't care	1	no	
percent_of_BW	don't care	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	0.248	0.248	no	Kbps - set for slowest burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 3: ri_277_1 Div a distant_warmup block

3 Overview

This observation is the third of the active ring scans. It occurs in a proximal orbit where the spacecraft passes through the ring plane just inside of the rings. The pointing design sweeps the central beam across the rings starting from the inner C-ring after the spacecraft finishes turning onto the IVD pointing profile (See fig. 1.) The spacecraft is outbound from the ring plane when the turn to the IVD pointing profile completes and range to the beam footprint varies from around 56000 km up to about 114000 km. The beam footprint size which sets the real aperture resolution varies from 340 km to around 680 km while looking at the rings. The beam footprint is moved slowly over the course of about two hours to allow many looks to accumulate. The pointing design keeps the beam aimed at a point along the line joining the sub-spacecraft point in the ring plane with the center of Saturn. This ensures that iso-range contours in the ring plane will be nearly parallel to iso-radius contours. Range compression processing can then be used to improve radius resolution from the real aperture limit. How much improvement will depend on signal strength, and ambiguity limitations. The radar mode (ie., bandwidth) is varied during this scan to allow for the best possible range resolution. The signal strength was estimated assuming a normalized backscatter of 1.0. The high spacecraft velocity leads to very high doppler shifts, so doppler ambiguities are unavoidable and doppler processing is not expected to be useful. The minimum PRF is also limited by the instrument command parameters, and range ambiguities will be present in much of the data. Since many looks are accumulated, and the rings are effectively a 1-D target, a deconvolution algorithm should be able to unravel the range ambiguities. Limitations on the number of instructions will also introduce some time domain clipping. The high range to the ring plane requires multiple bursts in flight for the more distant parts of the scan which placed further limitations on the PRF used.

4 Trigger Time Error and Downlink Data Loss

This observation and the previous RI 276 observation were affected by a 100 second trigger time error. Due to this error, the range and frequency gates were mis-aligned which causes both time and frequency domain clipping. The range gate refers to the time during which echo energy is expected to arrive back at the spacecraft. The frequency gate refers to the range of Ku-band frequencies over which the chirp echo will occur including the effect of doppler shift. Normally, the IEB generating software computes values for the receive window delay and the chirp start frequency based on the expected delay and frequency of echoes from the center of beam 3. A trigger time error means these values were computed for a time-shifted point in the trajectory. The impact of this error depends on how range and doppler vary during the observation. The impact is most severe on the scatterometer mode divisions which have less frequency margin. Any processing algorithm will need to account for the time and frequency domain clipping in these two observations.

This observation also suffered from significant data loss due to problems at the DSN. Only data from the C and B-rings are available covering radii up to about 108000 km. The dust detection experiment data which were supposed to occur at the very start of the observation also appear to be lost.

5 Dust Detection Experiment

This observation contained a dust detection experiment during the ring plane crossing which occurred at the start of the observation time. Division B in the configuration file was manually replaced with a special block of scatterometer mode data for this purpose. However, this data did not make it through the downlink and is not available. A repeat of this dust detection experiment was captured in the last active rings observation (ri 282).

6 Revision History

1. Apr 6, 2017: Initial Release

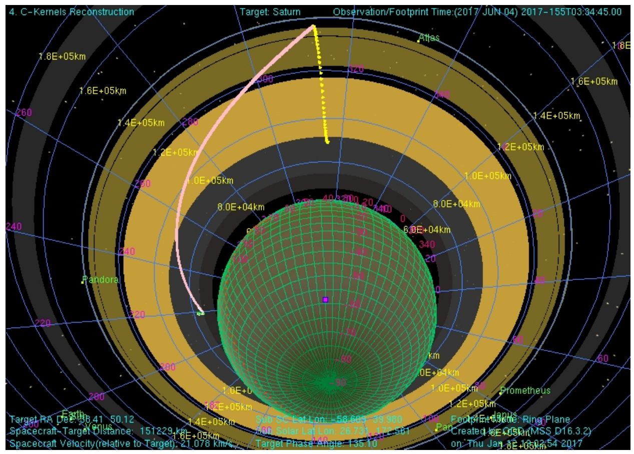

Figure 1: PDT view of RI 277 observation.

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	35.0	no	
end_time (min)	varies	43.0	no	
time_step (s)	don't care	10.0	no	manually set
bem	00100	00100	no	
baq	varies	5	no	5 - 8-8 for longer range
csr	8	0	yes	0 - fixed attenuator
noise_bit_setting	varies	4.0	no	
dutycycle	0.70	0.70	no	
prf (Hz)	don't care	1300	no	
tro	don't care	6	no	
number_of_pulses	don't care	70	no	
n_bursts_in_flight	1	1	no	
percent_of_BW	100	100.0	yes	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	varies	190.000	no	
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: ri_277_1 Div h scat_rings block

7 Acronym List

ALT	Altimeter - one of the radar operating modes
BAQ	Block Adaptive Quantizer
CIMS	Cassini Information Management System - a database of observations
Ckernel	NAIF kernel file containing attitude data
DLAP	Desired Look Angle Profile - spacecraft pointing profile designed for optimal SAR performance
ESS	Energy Storage System - capacitor bank used by RADAR to store transmit energy
IEB	Instrument Execution Block - instructions for the instrument
ISS	Imaging Science Subsystem
IVD	Inertial Vector Description - attitude vector data
IVP	Inertial Vector Propagator - spacecraft software, part of attitude control system
INMS	Inertial Neutral Mass Spectrometer - one of the instruments
NAIF	Navigation and Ancillary Information Facility
ORS	Optical Remote Sensing instruments
PDT	Pointing Design Tool
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
RMSS	Radar Mapping Sequencing Software - produces radar IEB's
SAR	Synthetic Aperture Radar - radar imaging mode
SNR	Signal to Noise Ratio
SOP	Science Operations Plan - detailed sequence design
SOPUD	Science Operations Plan Update - phase of sequencing when SOP is updated prior to actual sequencing
SSG	SubSequence Generation - spacecraft/instrument commands are produced
SPICE	Spacecraft, Instrument, C-kernel handling software - supplied by NAIF to use NAIF kernel files.
TRO	Transmit Receive Offset - round trip delay time in units of PRI